

SEMESTER 5

HEAT TRANSFER

Course Code	PBAOT504	CIE Marks	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	ESE Marks	40
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Engineering Thermodynamics	Course Type	Theory

Course Objectives:

1. The fundamentals of heat transfer as they relate to the design of engineering systems and devices that involve the transport of thermal energy or heat will be covered in this course.
2. The subject covers the mathematical formulations and real-world applications of the heat transport mechanisms by conduction, convection, and radiation. Heating issues that arise in high-speed, high-temperature flows are also addressed.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to heat transfer and its relation to thermodynamics. Basic modes of heat transfer and the laws governing them. Fourier's law and derivation of general three-dimensional heat conduction equation and the boundary conditions. One dimensional steady state heat conduction in composite mediums and with variable thermal properties and heat generation. Idea of electrical analogy and use of thermal resistance and capacitance concepts. Idea of critical thickness of insulation. Heat transfer in extended surfaces and design of fins. One dimensional transient heat conduction analysis and the idea of lumped mass analysis and its validity. Use of similarity solutions for heat transfer problems in semi-infinite and infinite solids. Application of non-dimensional parameters Fourier number and Biot number and the use of transient temperature (Heisler's) charts	9
2	Free and forced convection and non-dimensional parameters. Nusselt, Prandtl and Eckert and Grashof numbers. Free convection in atmosphere. Free convection on a vertical flat plate. Empirical relation	9

	for heat transfer. Concept of Laminar and turbulent convective heat transfer analysis using the boundary layer concepts in flows between parallel plates. over a flat plate and in a circular pipe. Need and application of numerical techniques in solving heat transfer problems.	
3	Radiation Heat Transfer: Introduction to physical mechanism of radiation heat transfer. Radiation properties of materials and their wave length dependence. Planck's radiation Law. Wein's displacement law and Kirchoff's law. Formulation of radiation shape factors for different geometries Concept of radiosity. Stefan-Boltzmann law Heat exchange between non-black bodies. Design of radiation shields. Heat exchangers and their classifications and applications. Design of heat exchangers using LMTD and e-NTU methods.	10
4	Introduction Spacecraft Thermal Control: need of spacecraft thermal control –energy balance in a spacecraft – modes of heat transfer – principles of spacecraft thermal control. Devices and Hardware for Spacecraft TCS (Principles & Operation): passive thermal control - mechanical joints – heat sinks and doublers –thermal louvers and switches – heat pipes – thermal coating materials – thermal insulation – ablative heat transfer – active thermal control techniques: electrical heaters, HPR fluid systems, space borne cooling systems.	10

Course Assessment Method
(CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Exam-1	Internal Exam-2	Total
5	30	12.5	12.5	60

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
2 Questions from each module. - Total of 8 Questions, each carrying 2 marks (8x2 =16 marks)	2 questions will be given from each module, out of which 1 question should be answered. - Each question can have a maximum of 2 sub divisions. - Each question carries 6 marks. (4x6 = 24 marks)	40

Course Outcomes (COs)

At the end of the course students should be able to:

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Apply heat conduction problems with temperature dependent thermal properties, heat generation and across multi-layer materials.	K3
CO2	Solve forced and free convection problems using boundary layer concepts and empirical solutions. Use of important non-dimensional parameters	K3
CO3	Solve radiation problems using basic radiation laws like Planck's law, Wein's displacement law and Kirchoff's law	K3
CO4	Summarize the unique issues that arise in high-speed aircraft and the design of cooling systems and ablative heat shields.	K2

Note: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	-	-	-	-	-	-	-	2
CO2	3	3	3	3	-	-	-	-	-	-	-	2
CO3	3	3	3	3	-	-	-	-	-	-	-	2
CO4	3	1	1	1	-	-	-	-	-	-	-	2

Note: 1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Heat Transfer – A Practical Approach	Yunus A. Cengel	Tata McGraw-Hill, New Delhi	2003
2	Heat and Mass Transfer	P.K. Nag	McGraw-Hill publications	3 rd edition, 2011
3	Fundamentals of Engineering Heat & Mass Transfer	S.C. Sachdeva	Wiley Eastern Ltd., New Delhi	1981

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
Heat Transfer	J.P. Holman	McGraw-Hil-New York	1991	Heat Transfer
A Heat Transfer Text Book	John H. Lienhard	Prentice Hall Inc.	1981	A Heat Transfer Text Book
Heat Transfer, A Basic Approach	M. NecatiOzisik	McGraw-Hil-New York	2005	Heat Transfer, A Basic Approach

Video Links (NPTEL, SWAYAM...)	
Module No.	Link ID
Module - I	Heat Transfer, Chris Long & Naser Sayma, www.bookboon.com
Module - II	NPTEL Heat Transfer course for Mechanical Engineering, http://nptel.ac.in/courses/112101097/
Module - III	NPTEL Heat Transfer course for Mechanical Engineering, http://nptel.ac.in/courses/112101097/
Module - IV	NPTEL Heat Transfer course for Mechanical Engineering, http://nptel.ac.in/courses/112101097/

PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	Practical	Presentation
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		30

1. Project Planning and Proposal (5 Marks)

- Clarity and feasibility of the project plan
- Research and background understanding
- Defined objectives and methodology

2. Contribution in Progress Presentation and Question Answer Sessions (4 Marks)

- Individual contribution to the presentation
- Effectiveness in answering questions and handling feedback

3. Involvement in the Project Work and Team Work (3 Marks)

- Active participation and individual contribution
- Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**

- Adherence to the project timeline and milestones
- Application of theoretical knowledge and problem-solving
- Final Result

5. **Final Presentation (5 Marks)**

- Quality and clarity of the overall presentation
- Individual contribution to the presentation
- Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**

- Overall quality and technical excellence of the project
- Innovation and originality in the project
- Creativity in solutions and approaches